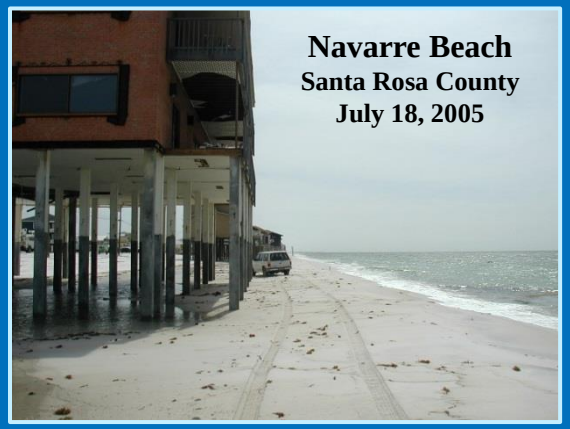
2014 FSBPA Annual Conference

Effectiveness of Beach Nourishment in Response to Sea Level Rise



Michael Walther, P. E., D. CE

Andrew Condon, Ph. D.

September 24, 2014

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Presentation

Outline

- **Beach Management Objectives**
- **Sea Level Rise in Florida -** ***historical & projected***
- **Effectiveness of Alternatives** ***– relative to Objectives***
  - **Beach Fill**
  - **Managed Retreat**
  - **Coastal Armoring – Seawalls**
- **Conclusions**

Classic

Beach Management Objectives

- **Protection - of upland property & infrastructure (storm-damage reduction)**
- **Preserve Land**
- **Enhance Recreational Beach (via creation, restoration, &/or expansion)**
- **Habitat Restoration (turtle nesting, shorebirds, &/or beach mice)**

Reference: USACE National Economic Development Manuals
Chapter 161 - Florida Statutes

Effectiveness of Beach Nourishment in Response to Sea Level Rise

		MSL Trend	
Location	**Period**	**(mm/yr)**	**(in/yr)**
Fernandina Beach	1897 - 2006	2.02	0.08
Mayport	1928 - 2006	2.40	0.09
Daytona Beach Shores	1925 - 1983	2.32	0.09
Miami Beach	1931 - 1981	2.39	0.09
Vaca Key	1971 - 2006	2.78	0.11
Key West	1913 - 2006	2.24	0.09
Naples	1965 - 2006	2.02	0.08
Fort Meyers	1965 - 2006	2.40	0.09
St. Petersburg	1947 - 2006	2.36	0.09
Clearwater Beach	1973 - 2006	2.43	0.10
Cedar Key	1914 - 2006	1.80	0.07
Apalachicola	1967 - 2006	1.38	0.05
Panama City	1973 - 2006	0.75	0.03
Pensacola	1923 - 2006	2.10	0.08
	Average:	2.10	0.08

Florida

Historical Sea Level Rise

Adapted From:
"Sea Level Variations of the United States 1854-2006", NOAA December 2009

Florida

Projected Sea Level Change - 2065

State-wide Lowest to Highest Range
per USACE

<u>Overall</u>: 0.24 feet to 2.91 feet

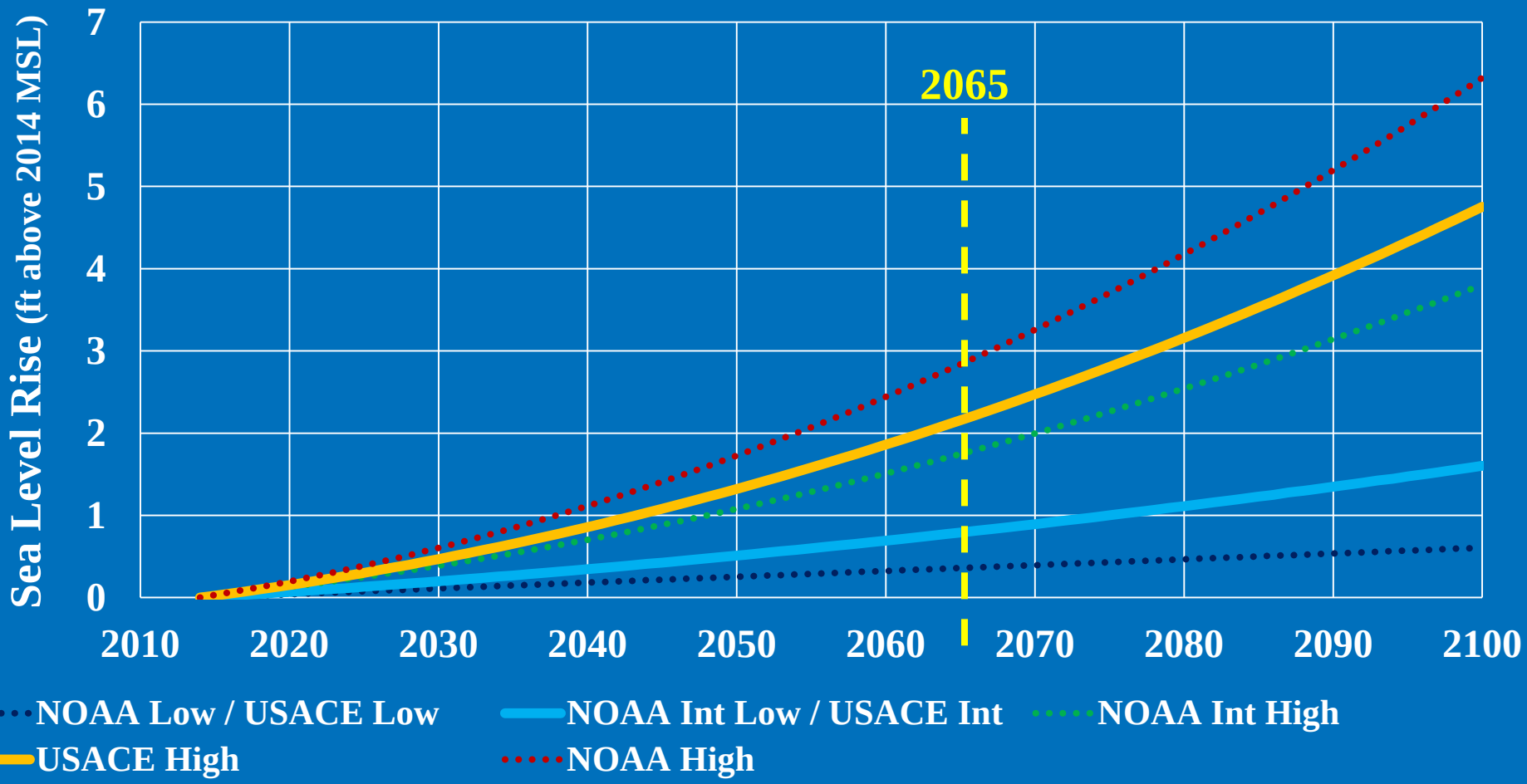
Adapted from: USACE Sea-Level Change Curve Calculator
https://corpsclimate.us/ccaceslcurves.cfm

Effectiveness of Beach Nourishment in Response to Sea Level Rise

Florida

Projected Sea Level Change

Florida: All Gauges Average



Adapted from: USACE Sea-Level Change Curve Calculator
https://corpsclimate.us/ccaceslcurves.cfm

Alternatives

- **Beach Fill**
- **Managed Retreat** ≡ **"No Action" to abate erosion**
- **Coastal Armoring – Seawalls**

Sea Level Rise

Effect on Beach Fills – future nourishment

to offset longshore sediment transport gradient & sea level rise

$$\frac{\partial V}{\partial t} = \underbrace{(h_* + B)\frac{\partial R_0}{\partial t}}_{\text{Volume required for present rate of SLR}} + \underbrace{W_*\left(\frac{\partial S}{\partial t} - \frac{\partial S_0}{\partial t}\right)}_{\text{Amount due to the increased SLR rate}}$$

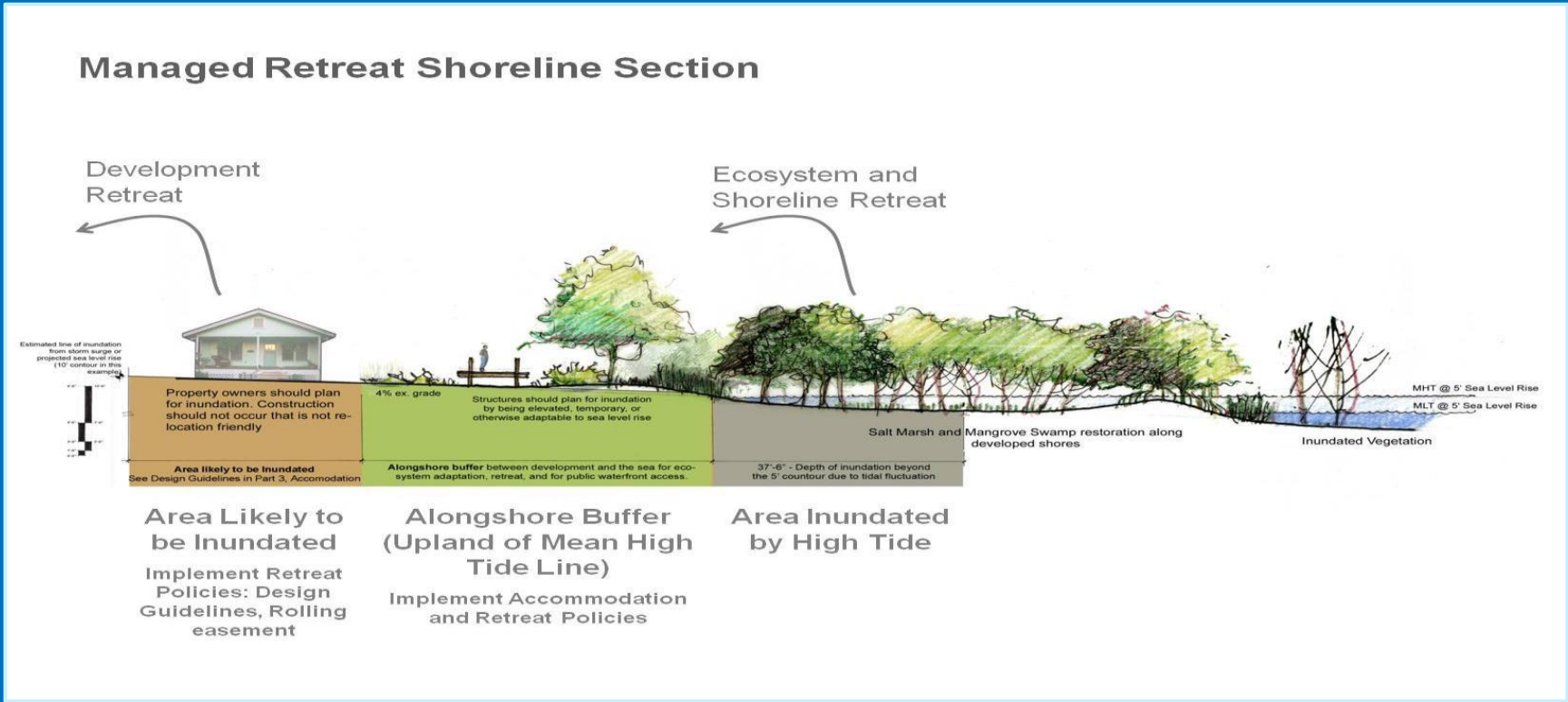
Where

- $\frac{\partial V}{\partial t}$ = Volumetric rate of nourishment addition per unit length of beach (cyds. / ft. / yr.)
- $\frac{\partial R_0}{\partial t}$ = Existing background erosion rate (ft. / yr.)
- $\frac{\partial S}{\partial t}$ = Rate of sea level rise (ft. / yr.)
- $\frac{\partial S_0}{\partial t}$ = Existing sea level rise rate (ft. / yr.)
- W_* = Width of the active beach profile (ft.)
- h_* = Depth of closure (ft.)
- B = Berm height (ft.)

Adapted from: Dean, R.G and Dalrymple, R.A., 2002. "*Coastal Processes with Engineering Applications*". Cambridge: Cambridge University Press, 475 p.

Managed Retreat ≡ "No Action"

- Allows the shoreline to migrate landward unimpeded.
- Buildings & infrastructure either demolished or relocated.



From: Beaver, J.W., "Climate Readiness Planning at the SWFRPC and CHNEP 2009 to 2013." October 17, 2013.

Sea Level Rise

Shoreline Recession: Bruun Rule

Assumes

1. **Profile shape does not change with respect to the water line.**
2. **The sand volume in the profile must be conserved.**

$$\Delta y = -R = -S\frac{W_*}{(h_* + B)}$$

Where

- Δy = -R = Horizontal shoreline recession
- S = Sea level rise
- W_* = Width of the active beach profile
- h_* = Depth of closure
- B = Berm height

Adapted from: Dean, R.G and Dalrymple, R.A., 2002. "*Coastal Processes with Engineering Applications*". Cambridge: Cambridge University Press, 475 p.

Sea Level Rise

Shoreline Recession: Dean Equilibrium Profile

Assumes

1. **Beach shaped to equilibrium by steady state sea conditions**
2. **Erosion 2-dimensional mass balance of accretion & erosion**
3. **Profile shape given by**

$$h = Ax^m$$

Where

- h **= stillwater depth above the equilibrated profile**
- x **= the horizontal distance from the shoreline**
- **m = exponent to fit**
- **A = Dimensional scale parameter related to sediment**

Adapted from: Dean, R.G and Dalrymple, R.A., 2002. "*Coastal Processes with Engineering Applications*". Cambridge: Cambridge University Press, 475 p.

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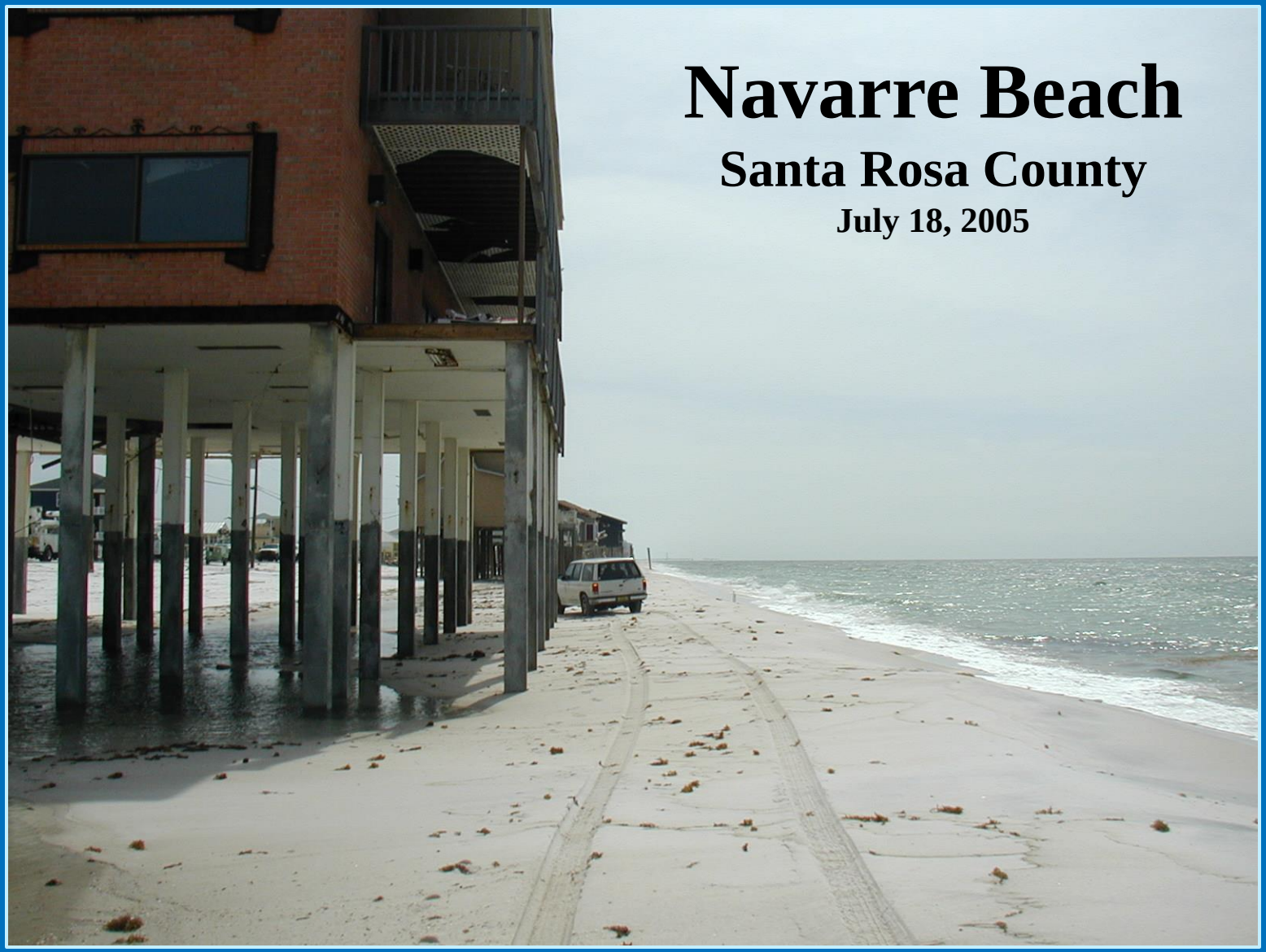

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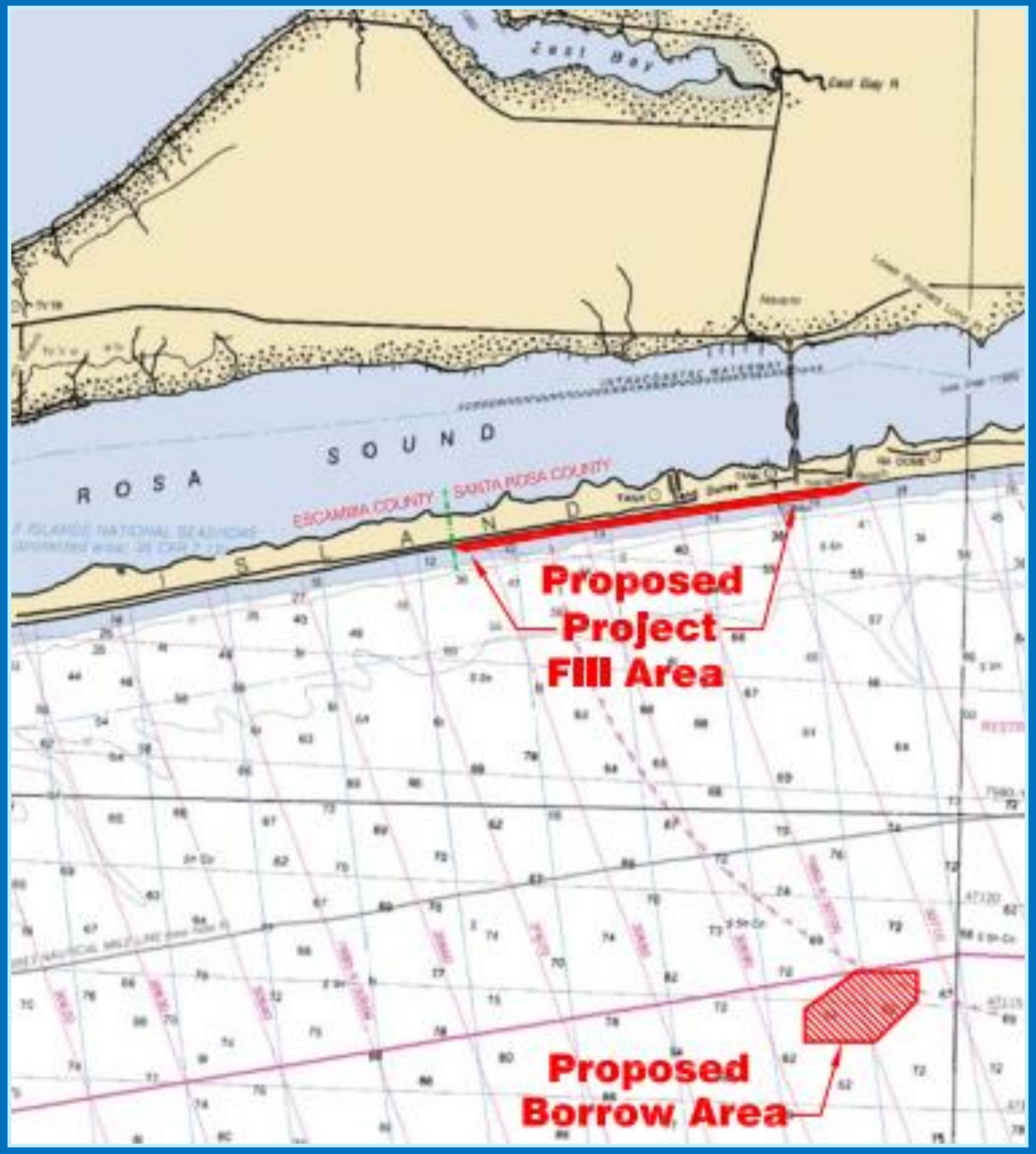

Navarre Beach

Santa Rosa County

Initial Construction:

2.95 Mcy

4.1 miles

136 cyds/ft

2006

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Effectiveness of Beach Nourishment in Response to Sea Level Rise

Photo From: Google Earth

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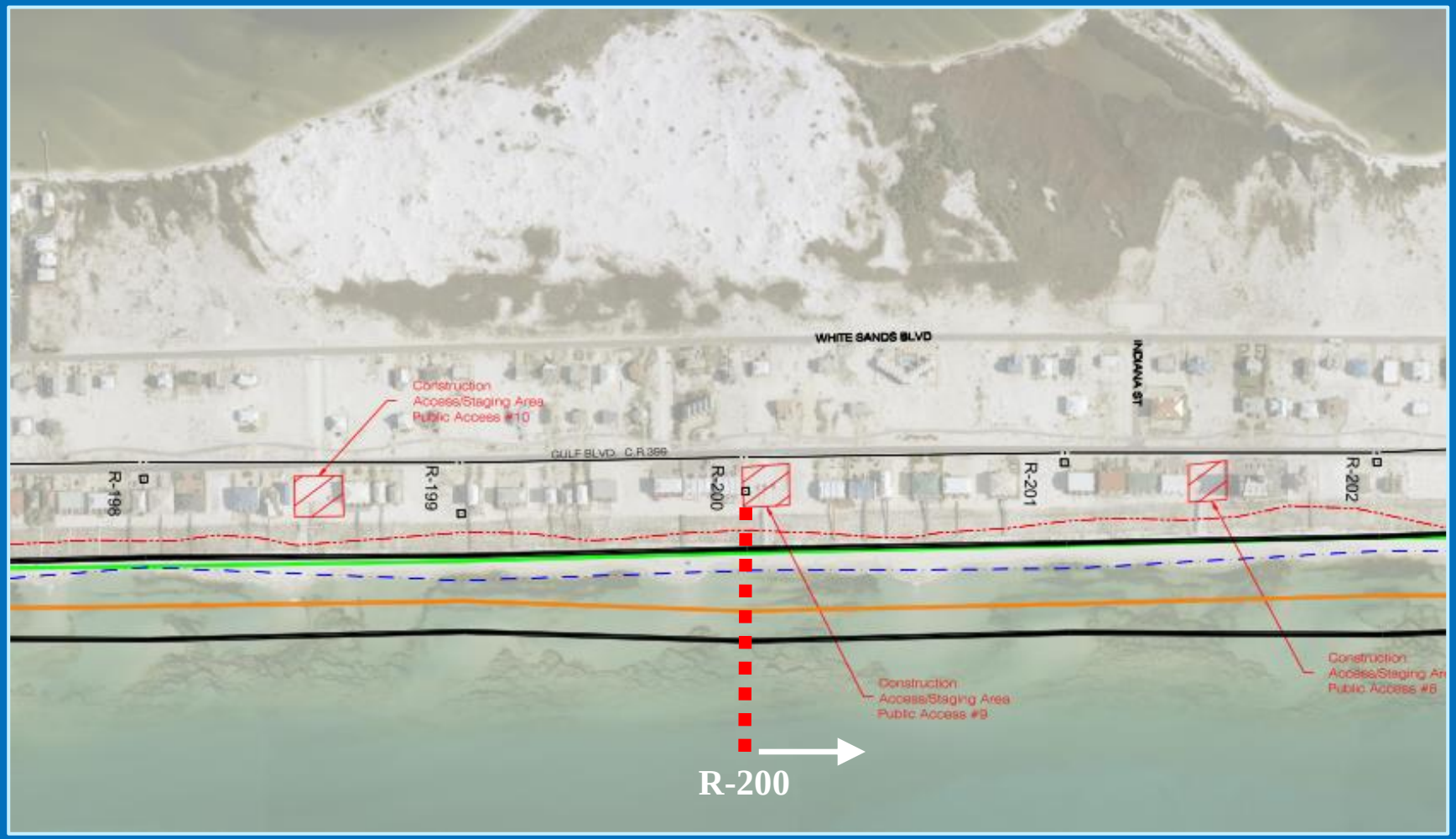
Navarre Beach - Santa Rosa County



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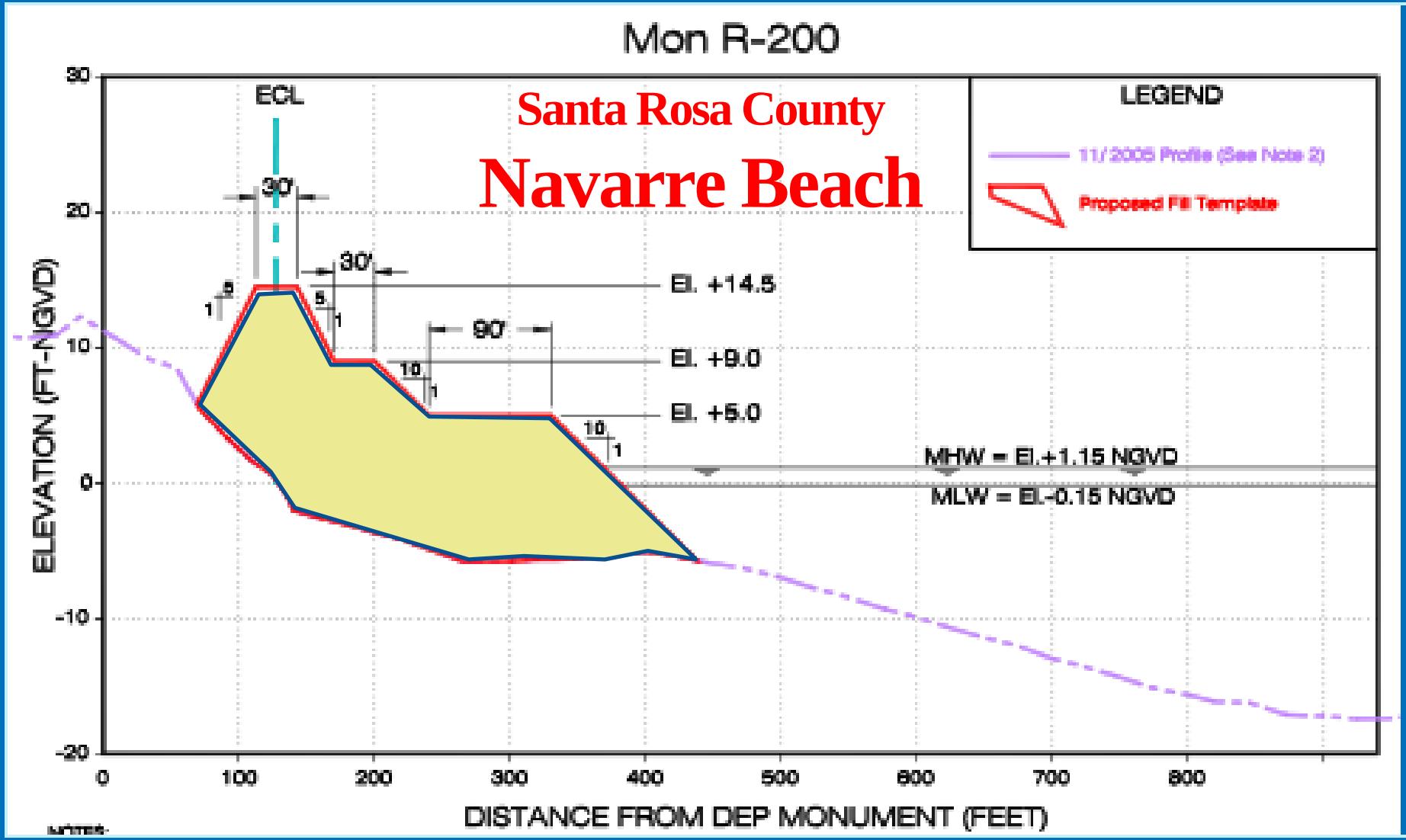
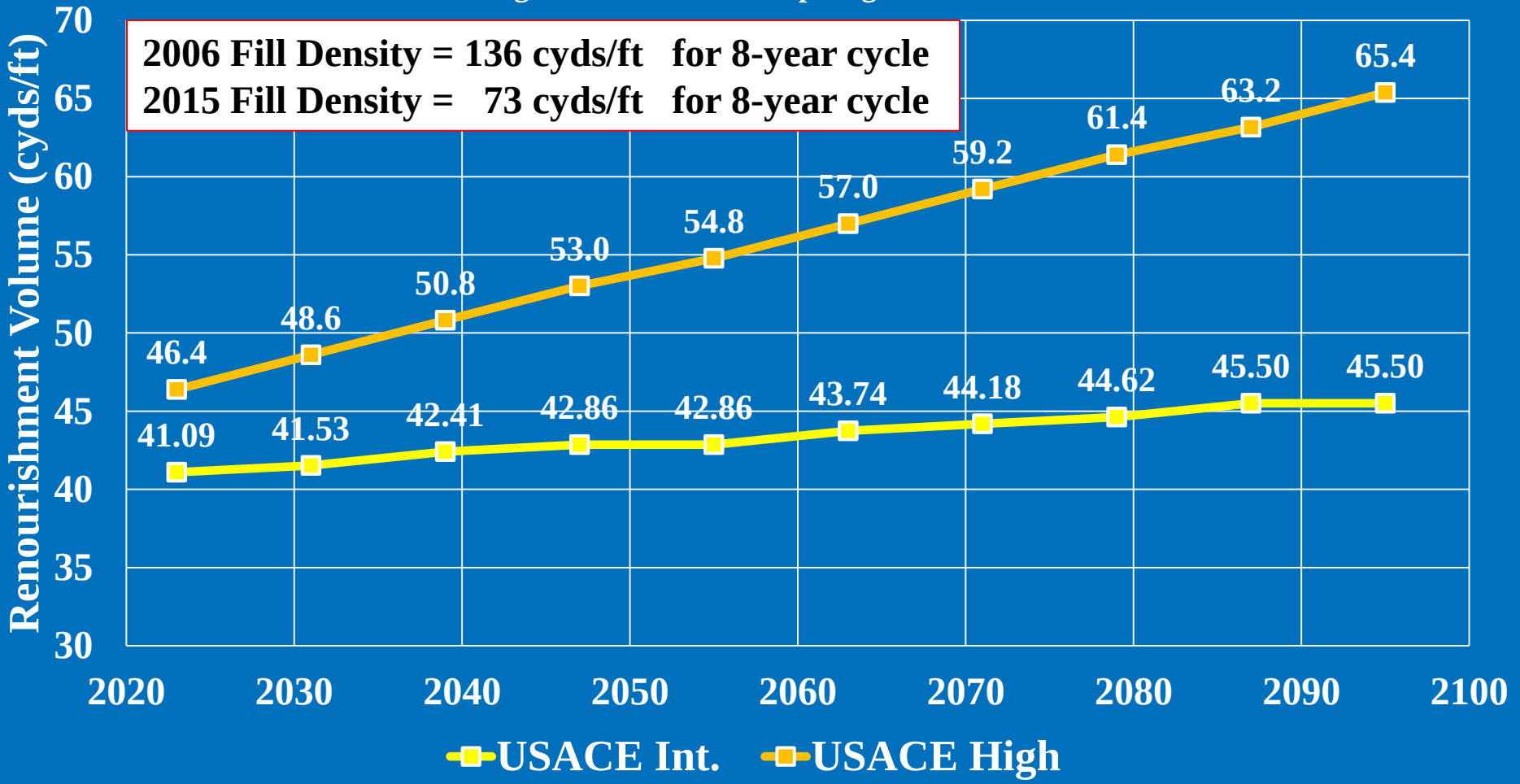


Navarre Beach - Santa Rosa County

Nourishment - future needs based on 8 year cycle

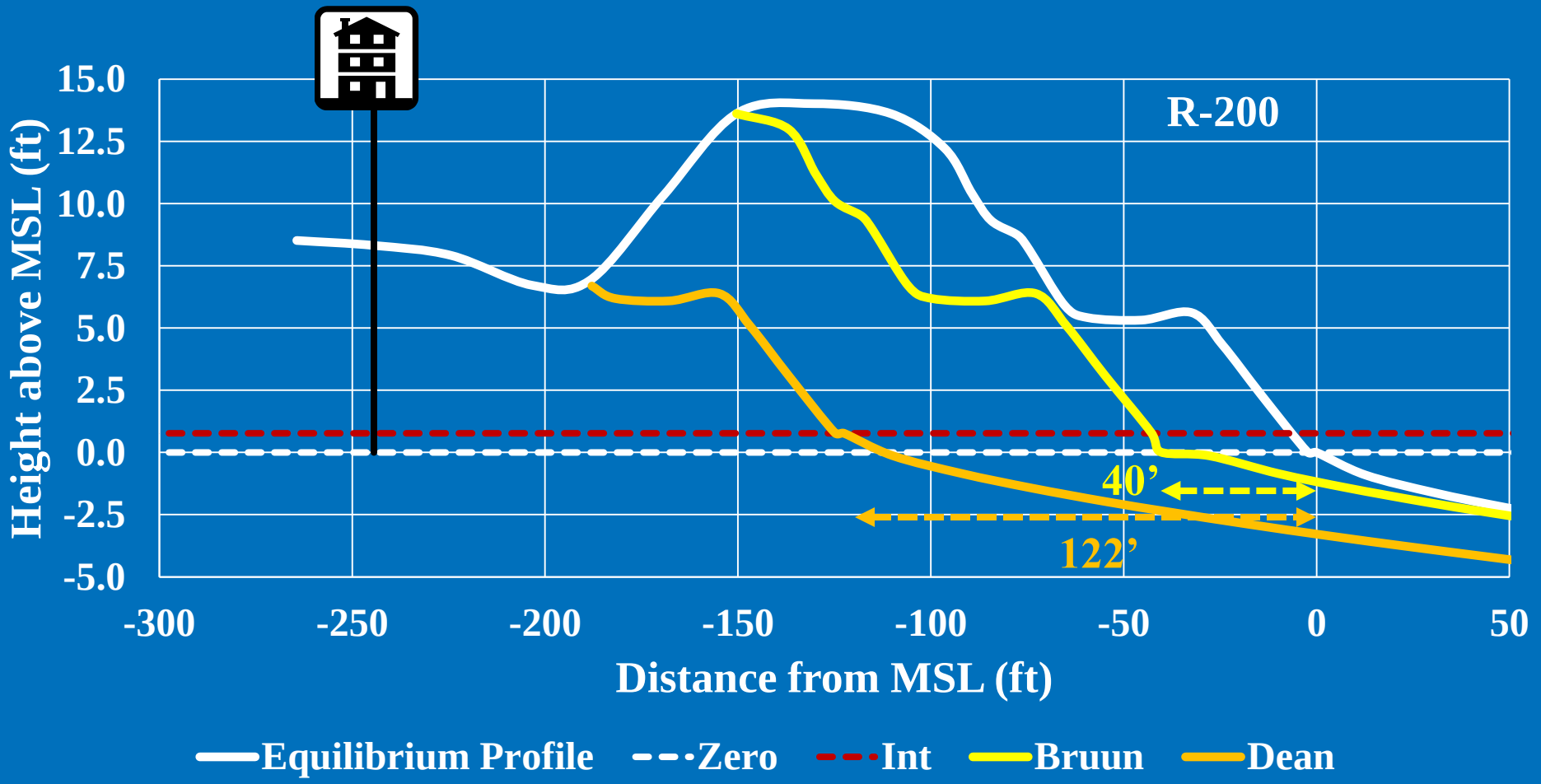
to offset longshore sediment transport gradient & sea level rise



Effectiveness of Beach Nourishment in Response to Sea Level Rise

Navarre Beach - Santa Rosa County

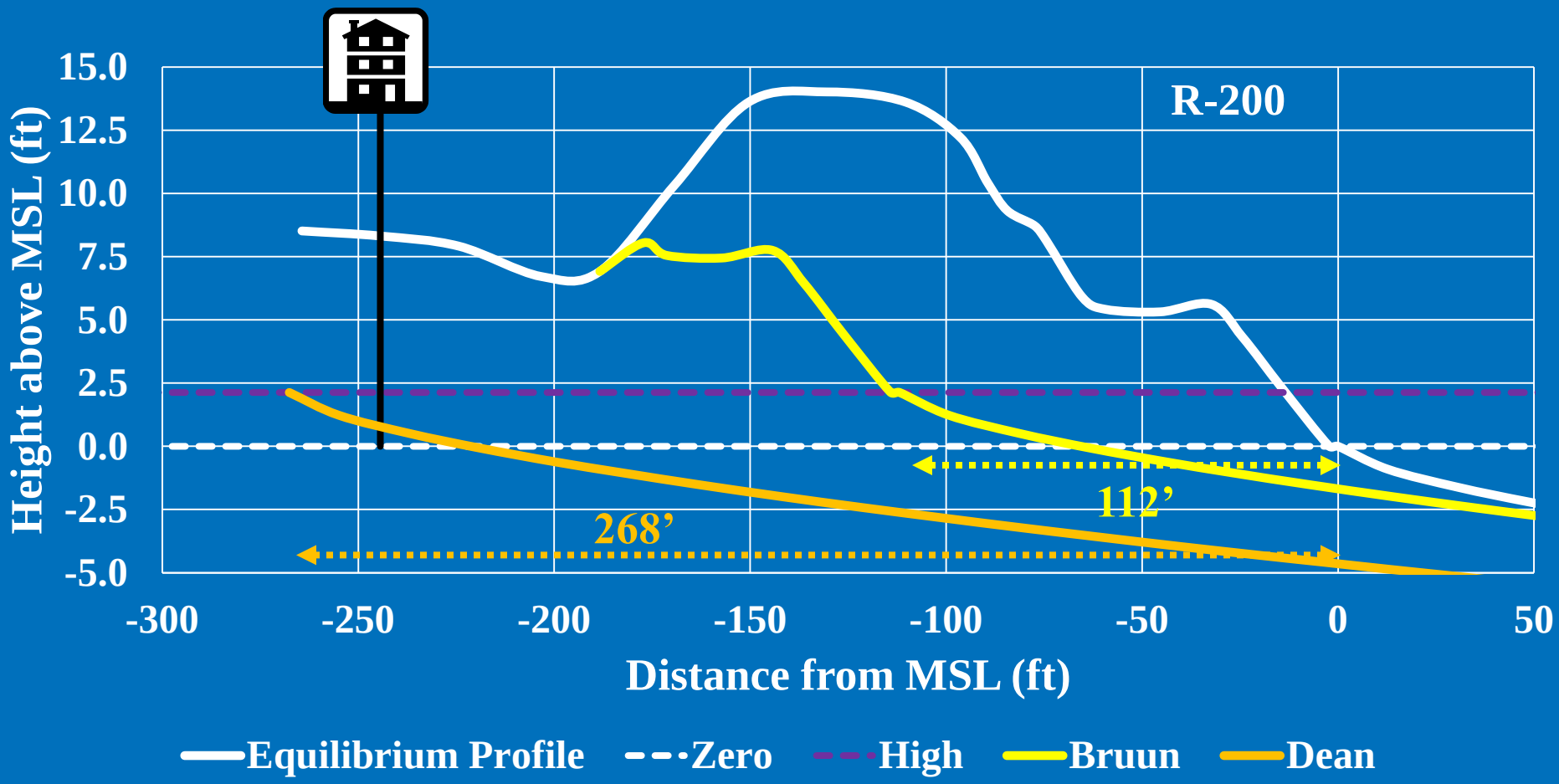
No Action - Intermediate Sea Level Change - 2065



Effectiveness of Beach Nourishment in Response to Sea Level Rise

Navarre Beach - Santa Rosa County

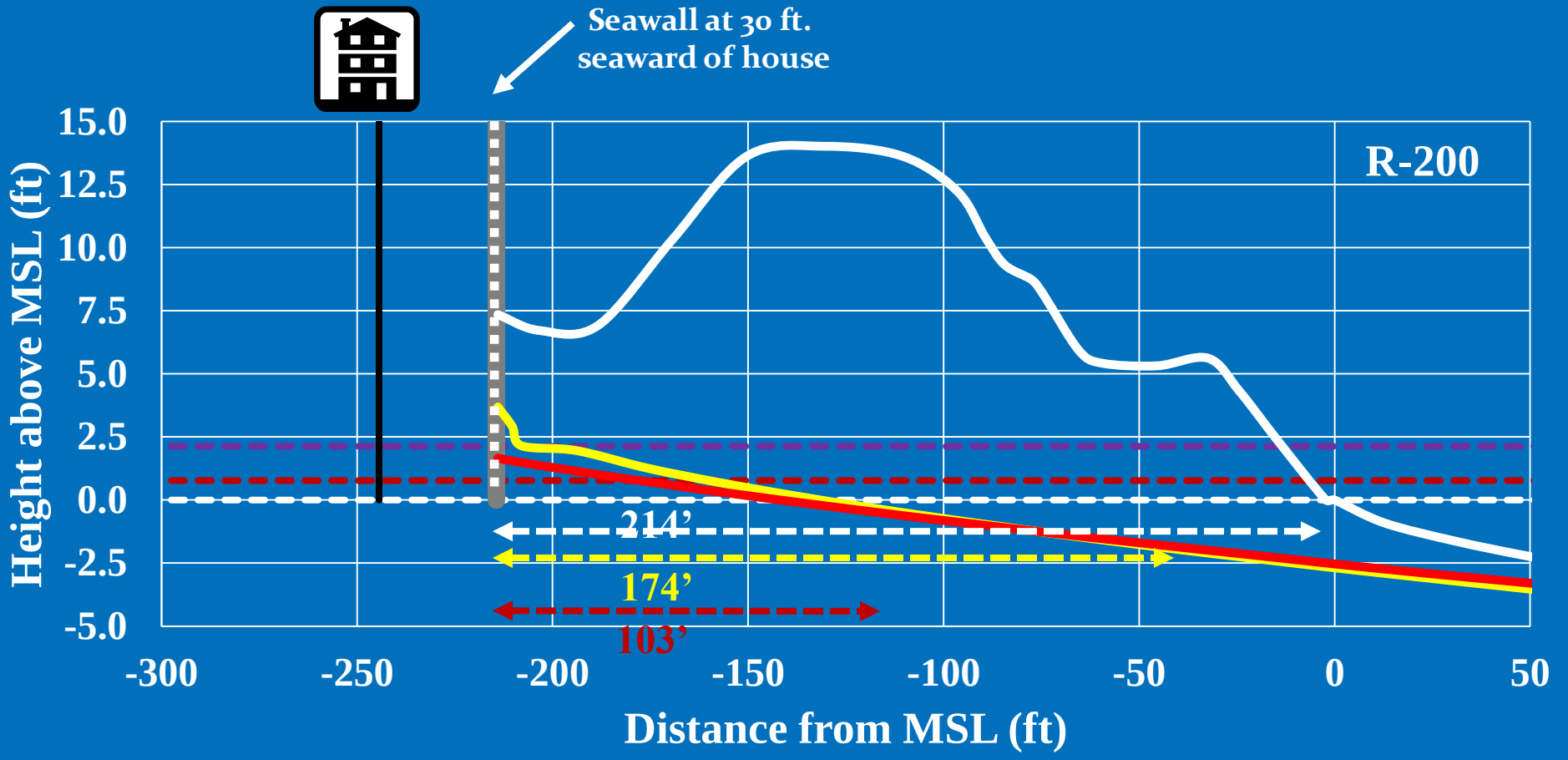
No Action - High Sea Level Change - 2065



Effectiveness of Beach Nourishment in Response to Sea Level Rise

Navarre Beach - Santa Rosa County

Seawall – by 2065



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Effectiveness of Beach Nourishment in Response to Sea Level Rise

Lovers Key - Lee County

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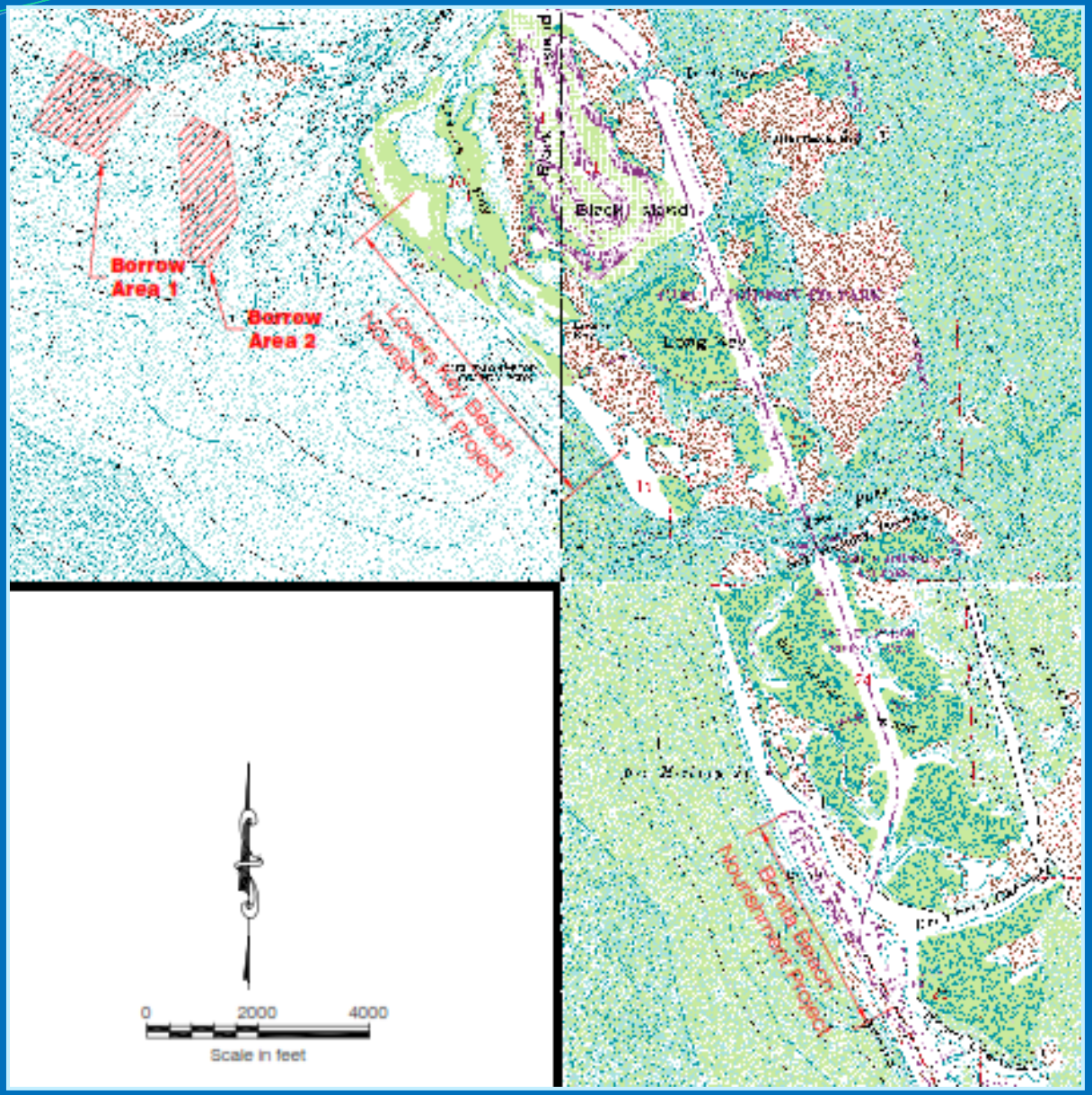

Lovers Key

Lee County

Initial Construction:

533,385 cy

1.1 miles

90cy/ft

2004

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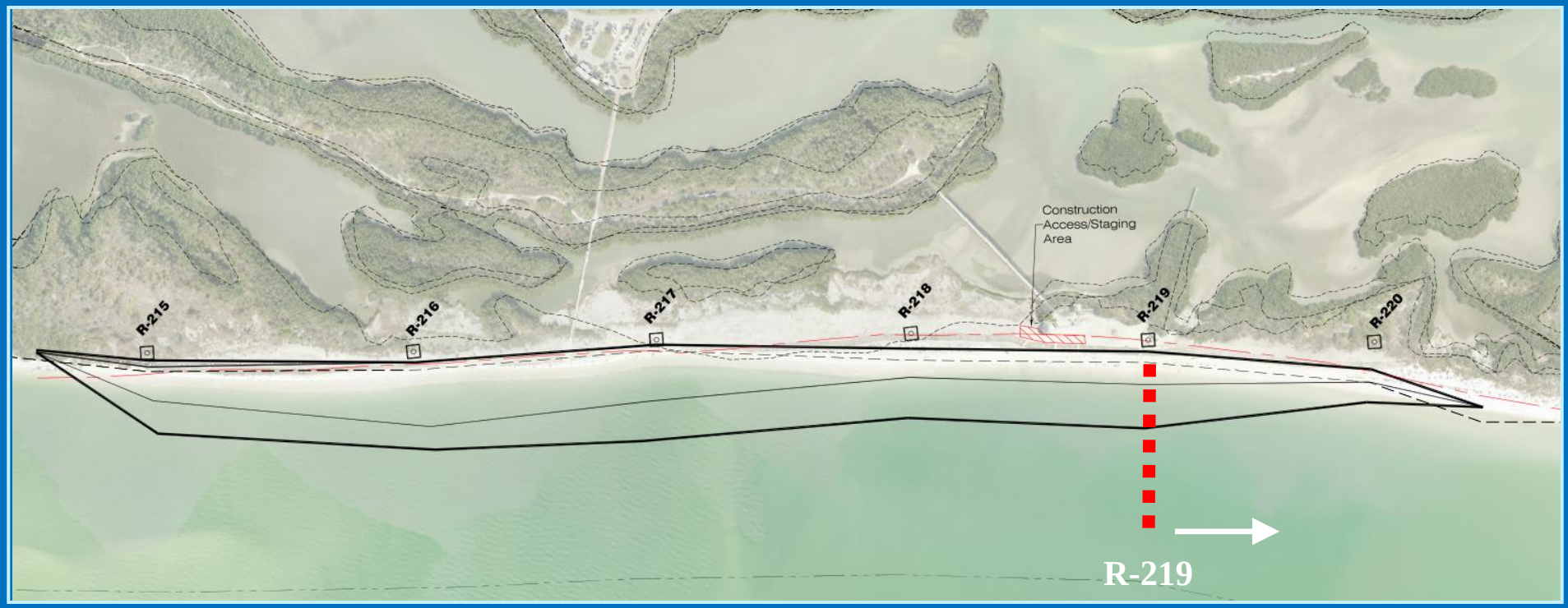
Lovers Key - Lee County



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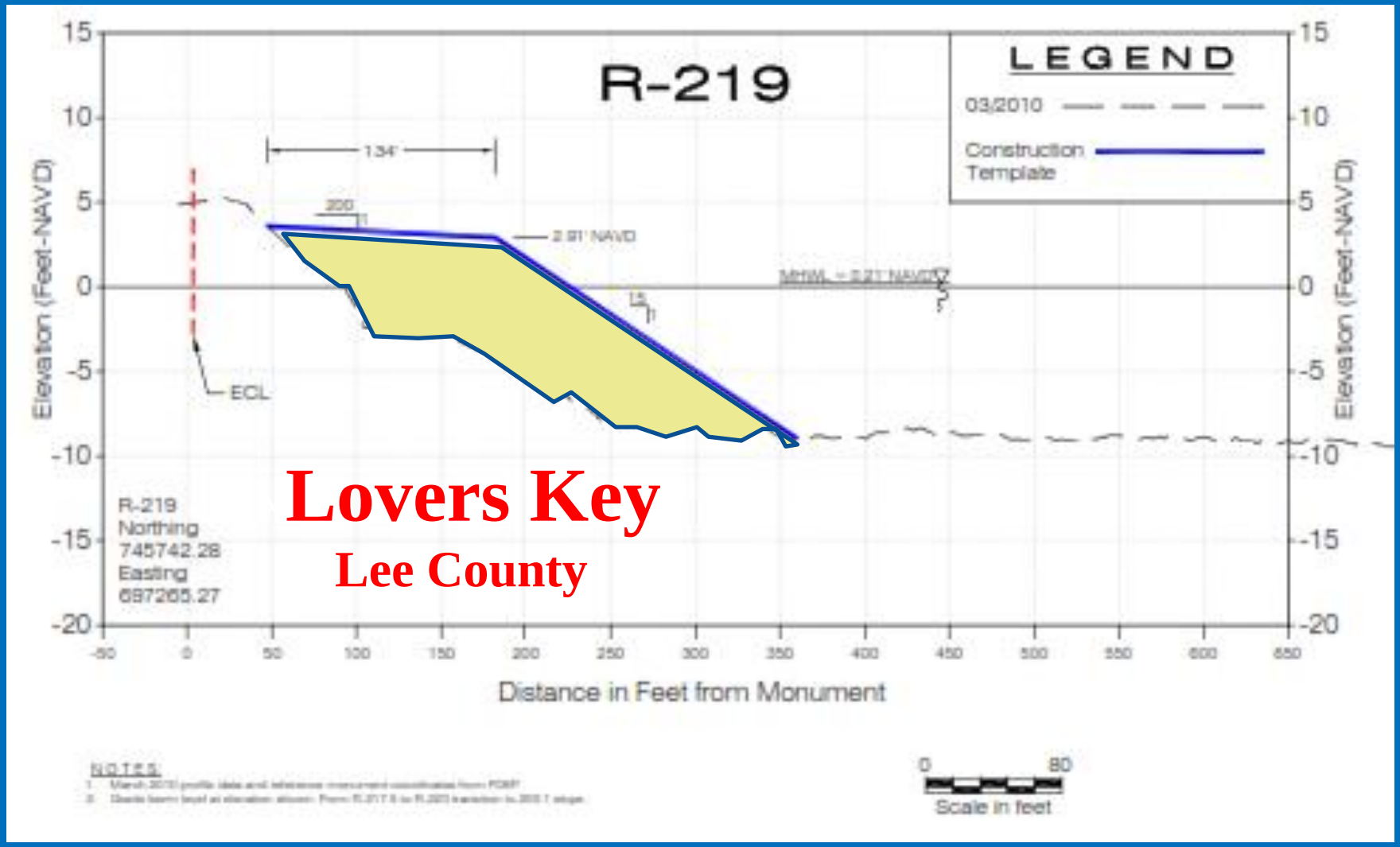

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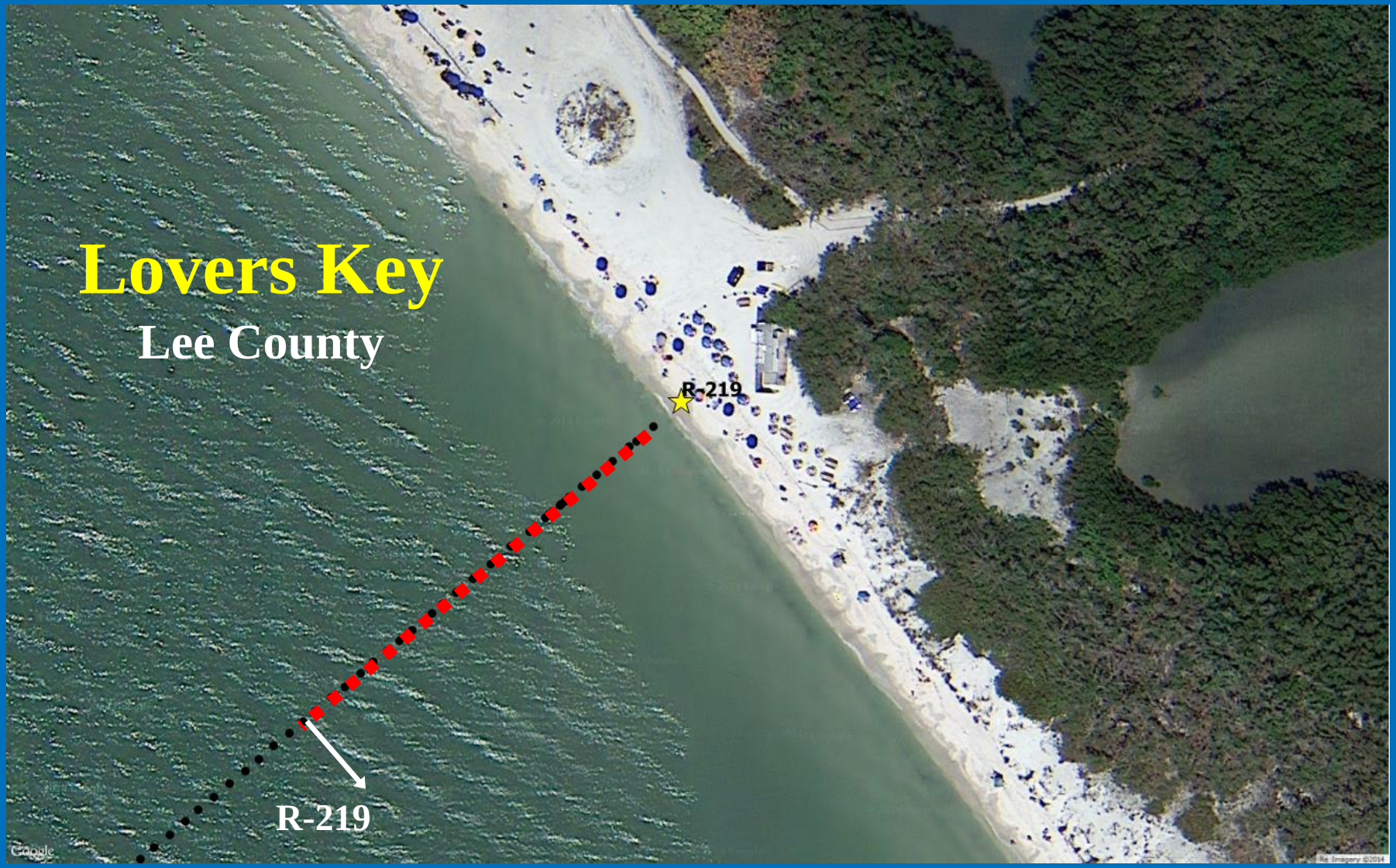

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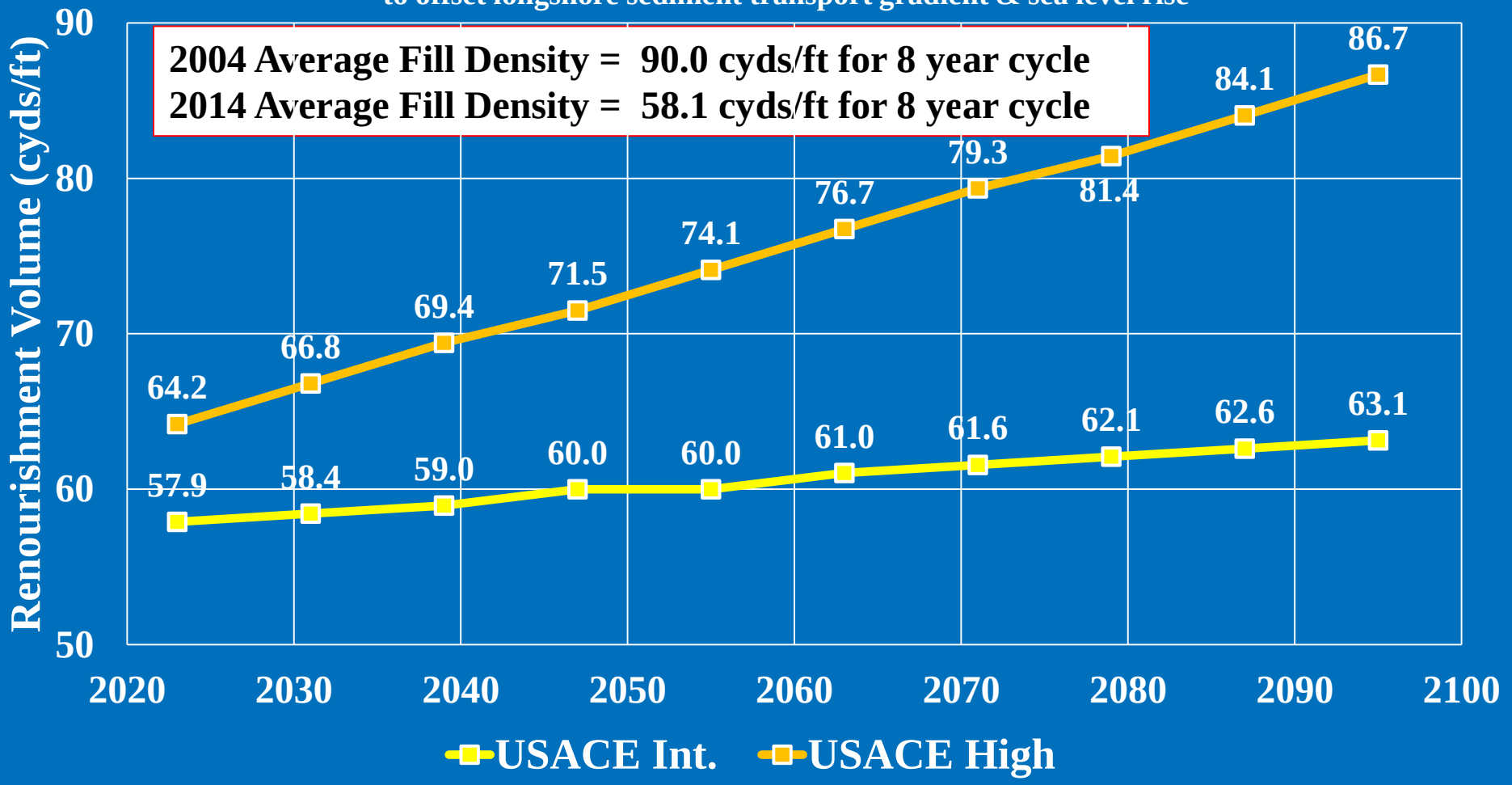
Lovers Key - Lee County

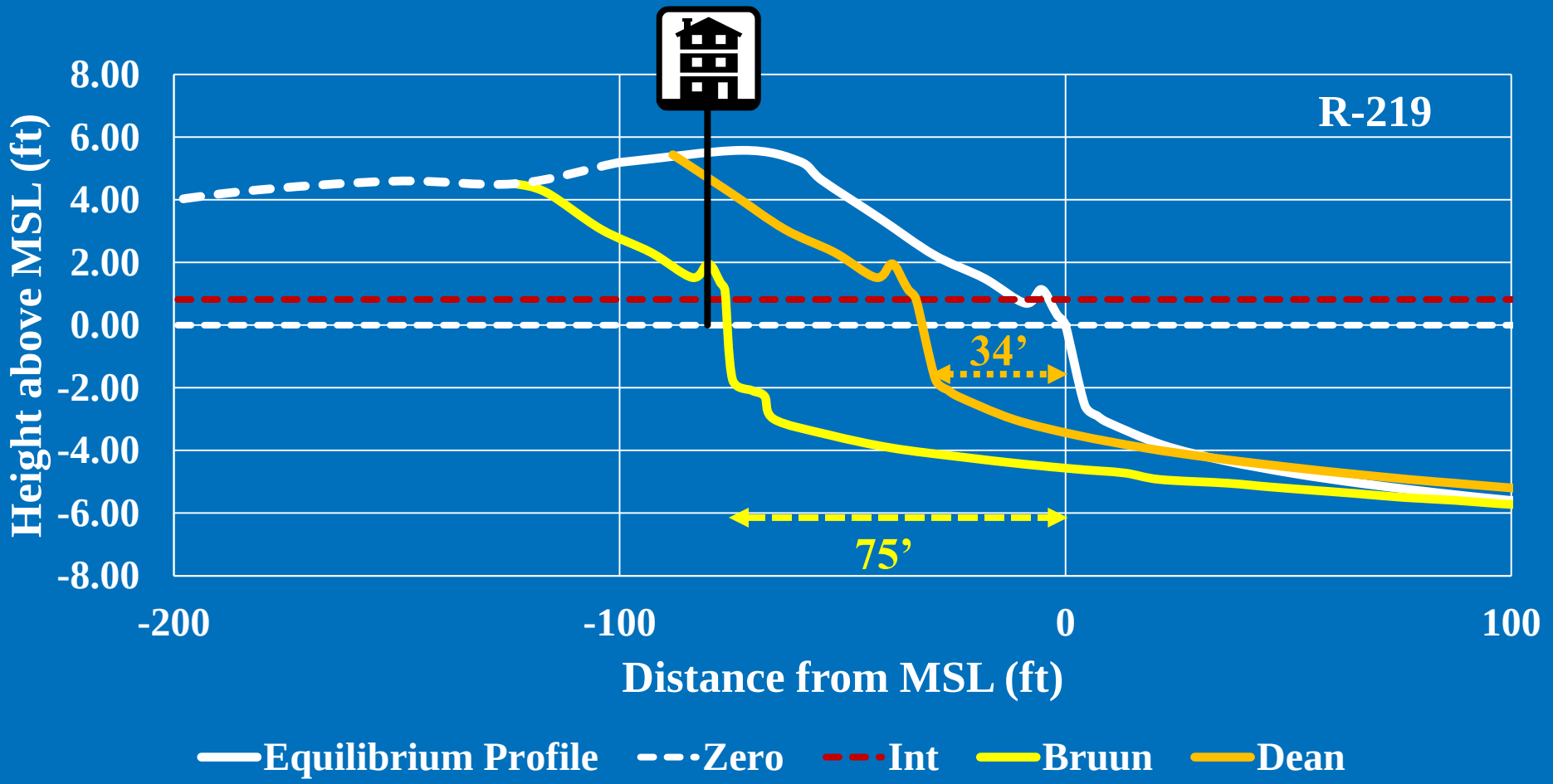
Nourishment - future needs based on 8 year cycle

to offset longshore sediment transport gradient & sea level rise



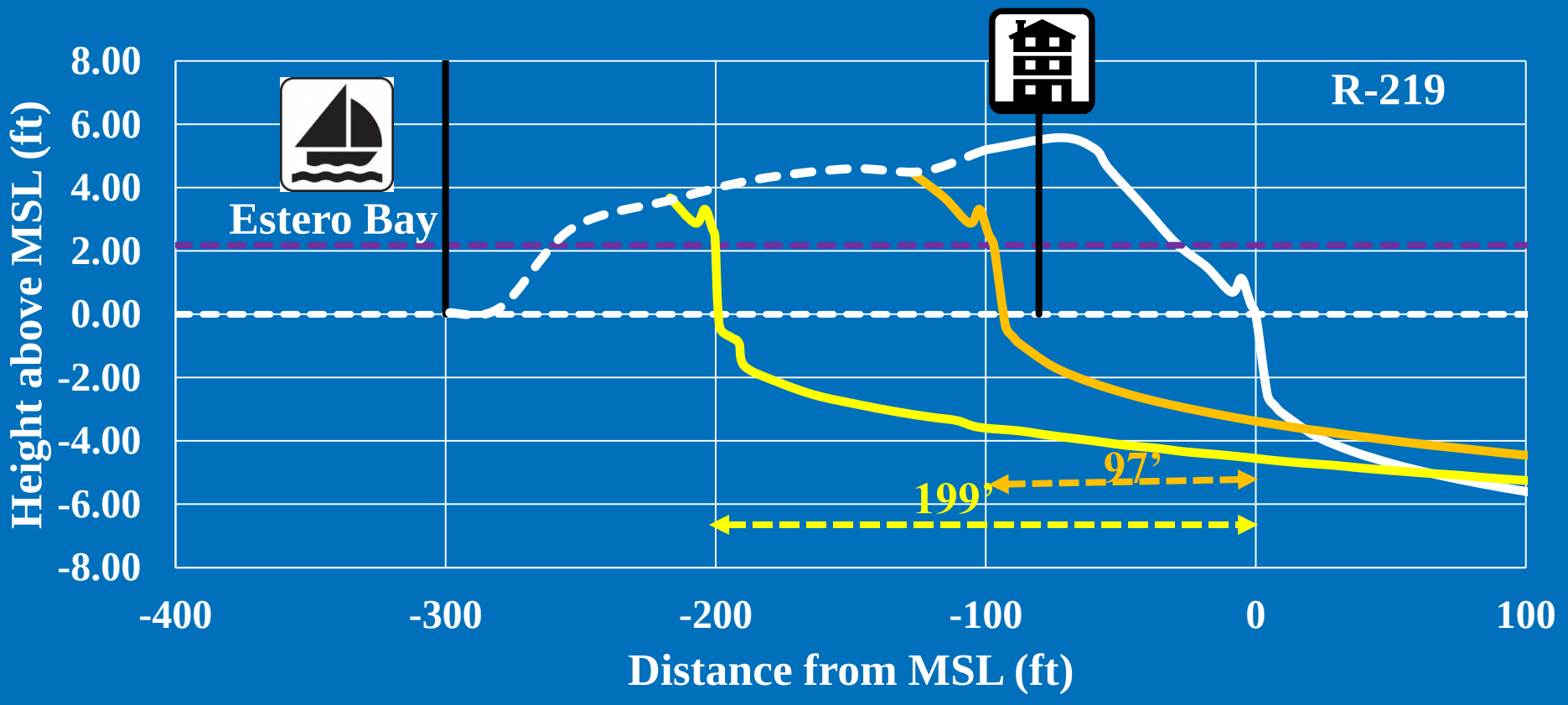
Lovers Key - Lee County

No Action - Intermediate Sea Level Change - 2065



Lovers Key - Lee County

No Action – High Sea Level Change - 2065



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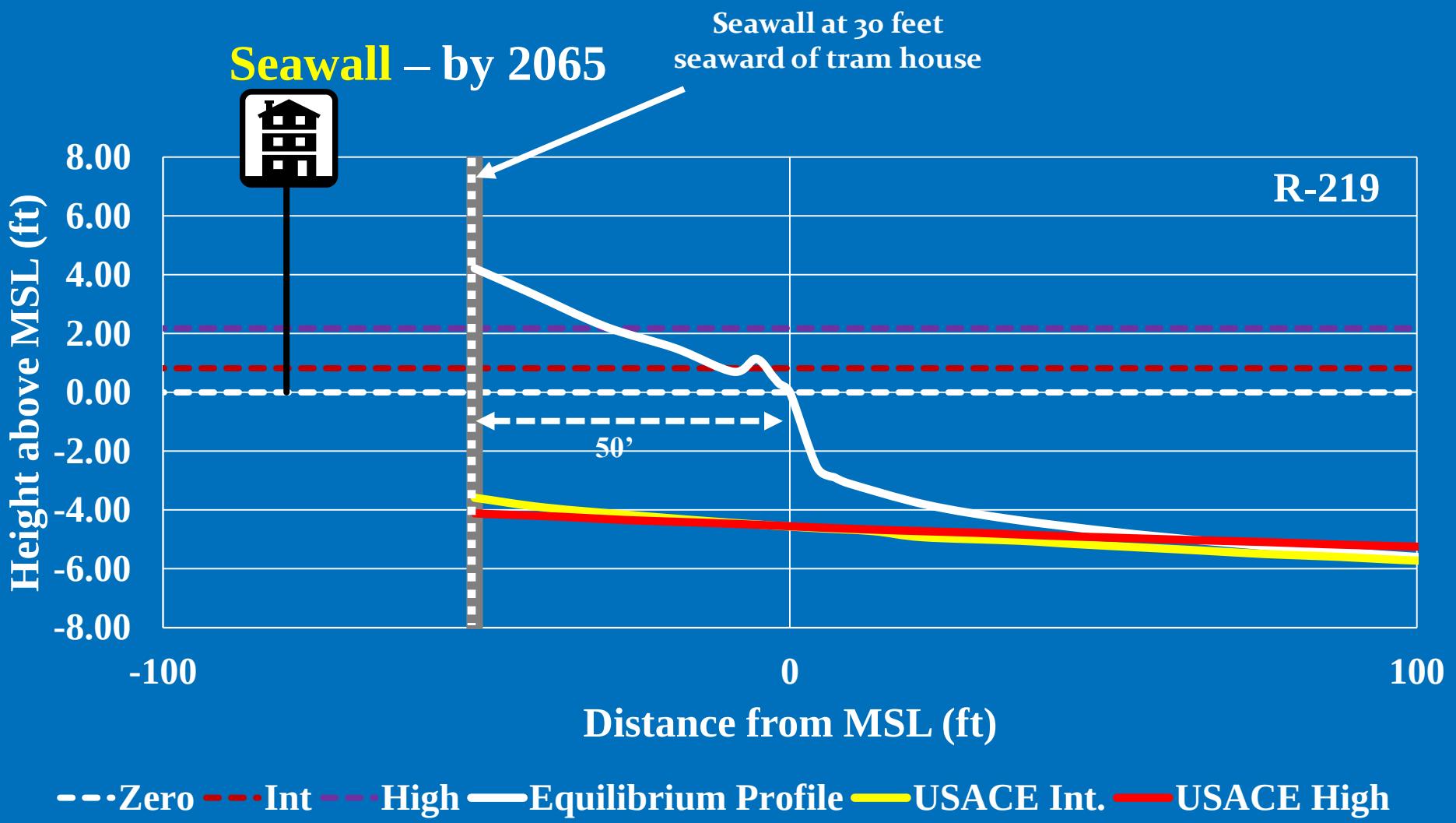

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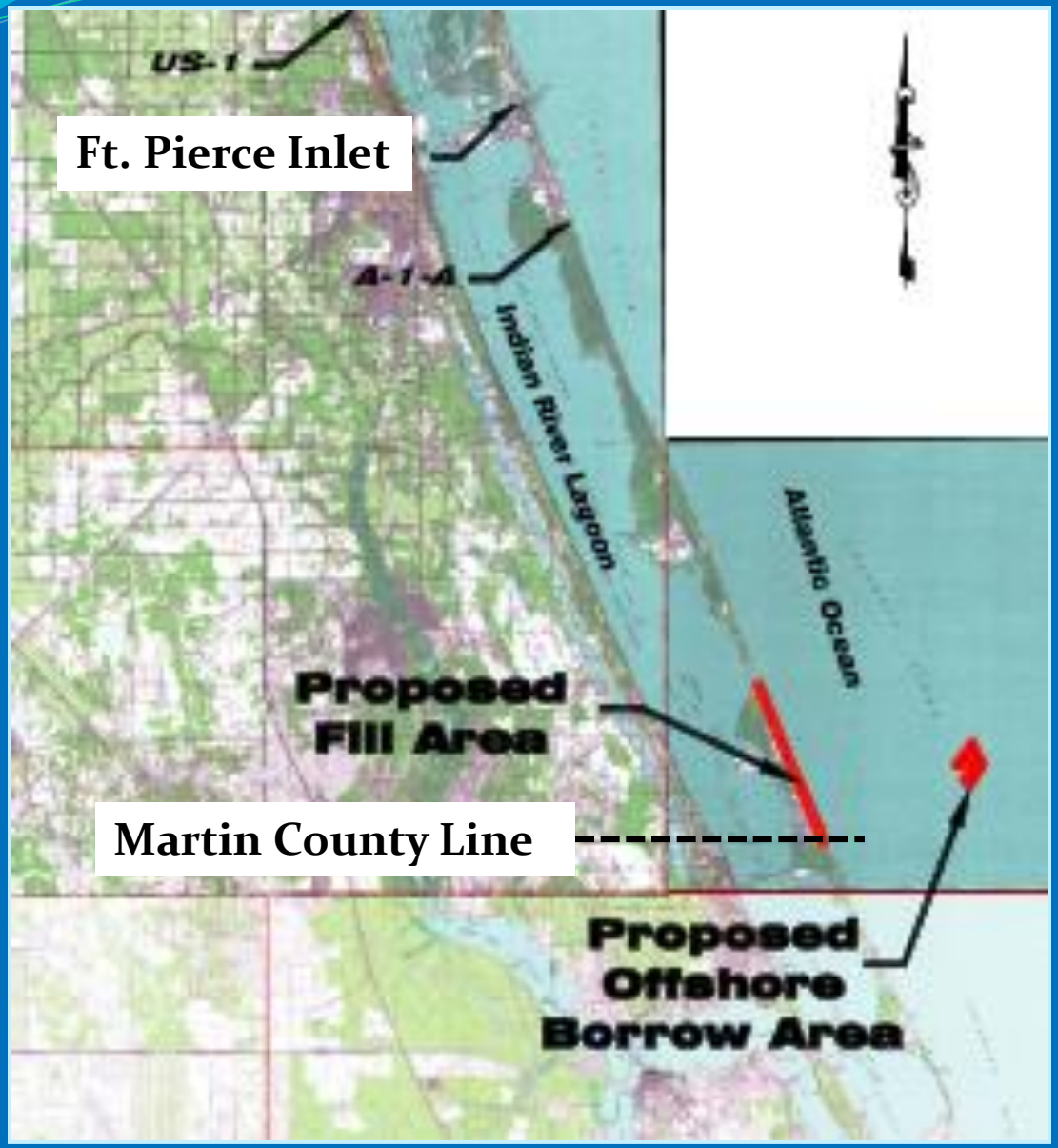


South County

St. Lucie County

Initial Construction:

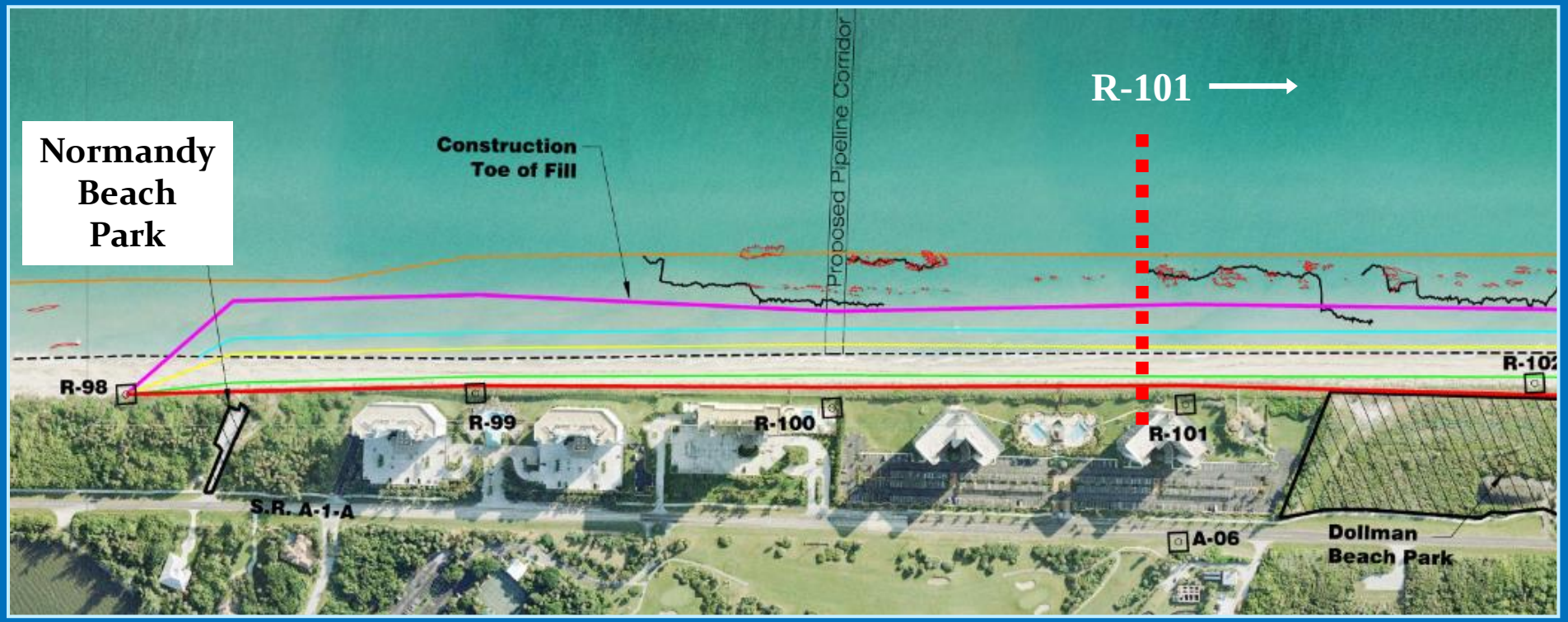
682,500 cy

3.4 miles

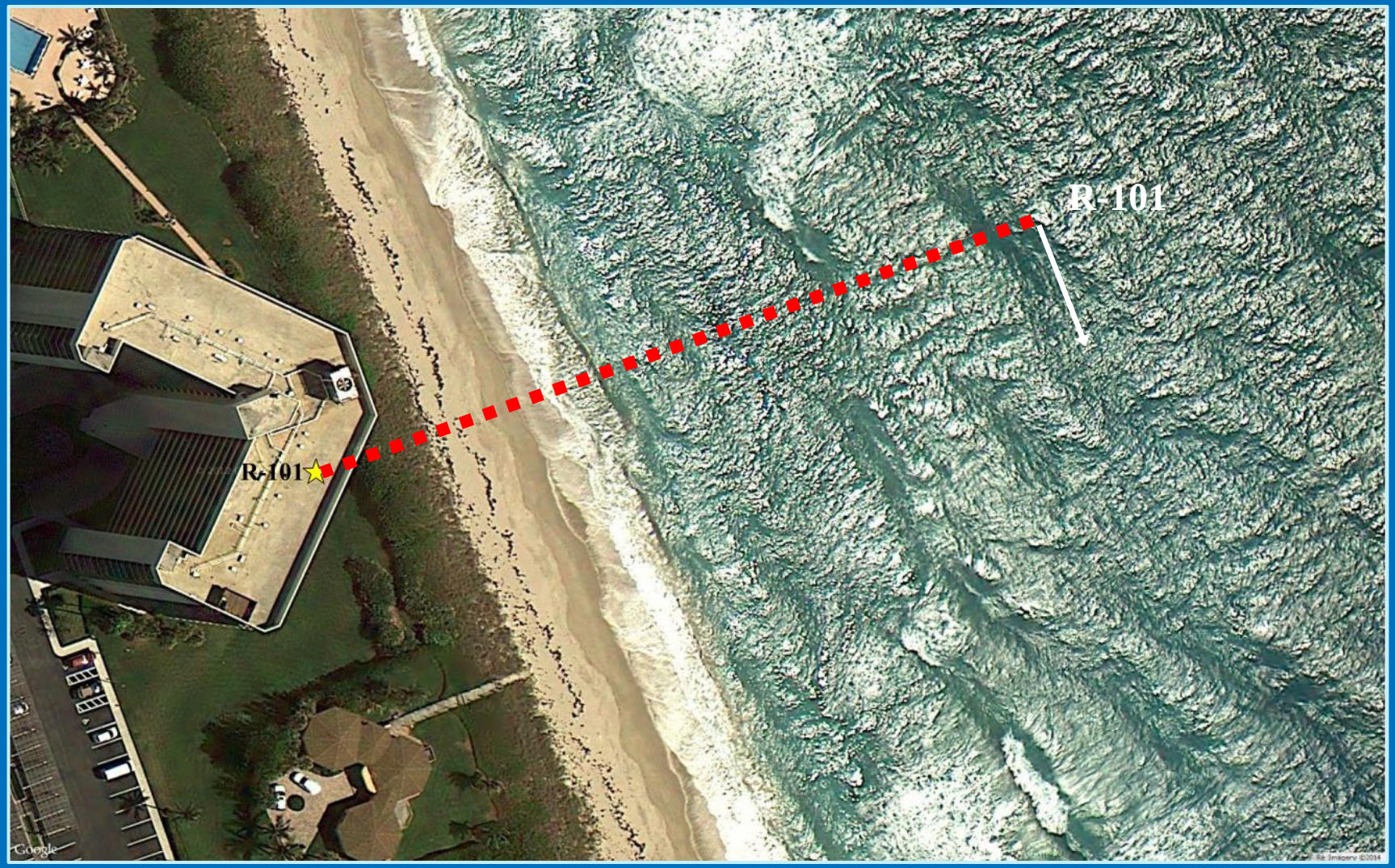
38.5cy/ft

2013

South County - St. Lucie County



South County - St. Lucie County



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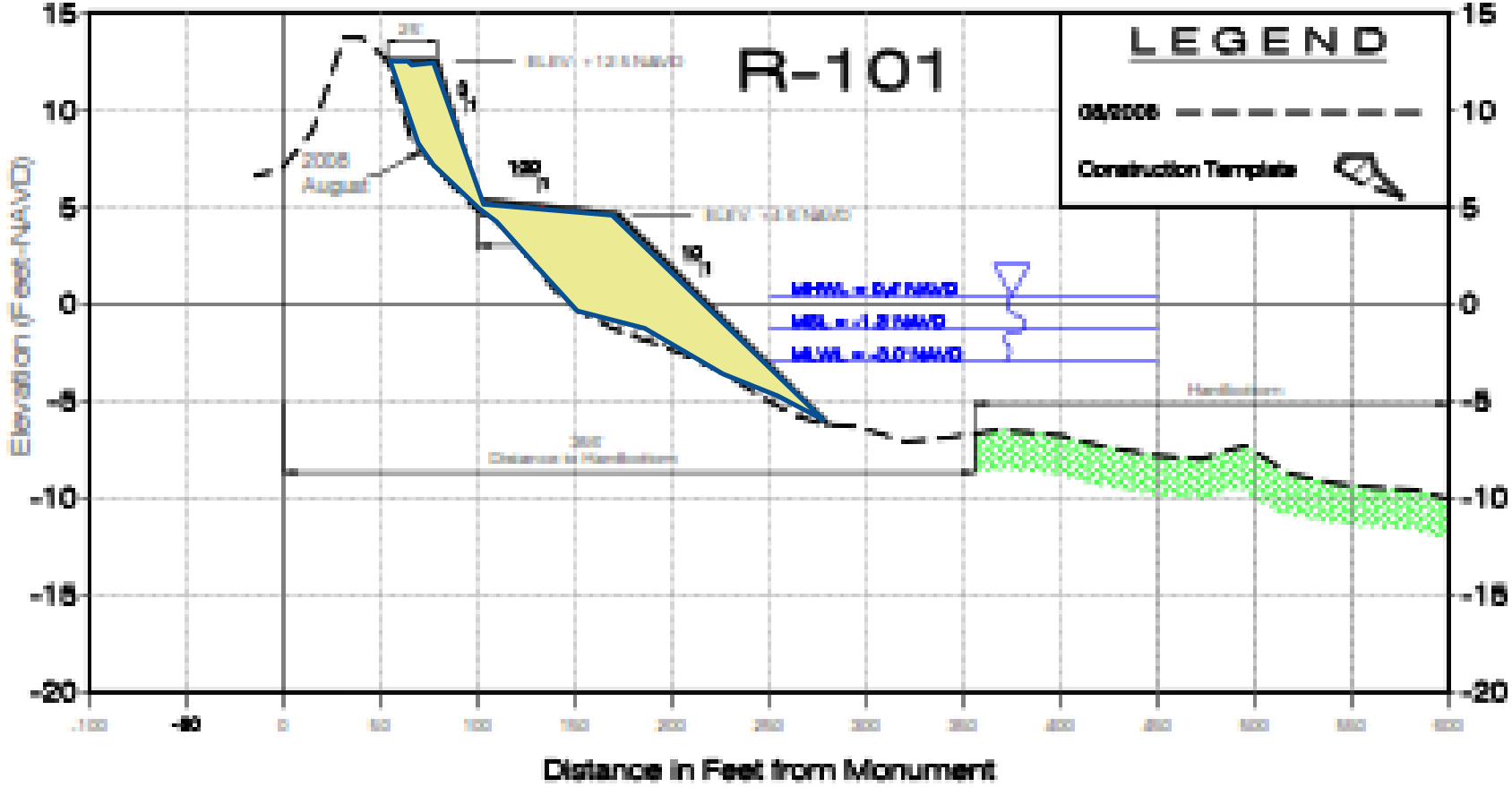
South County - St. Lucie County

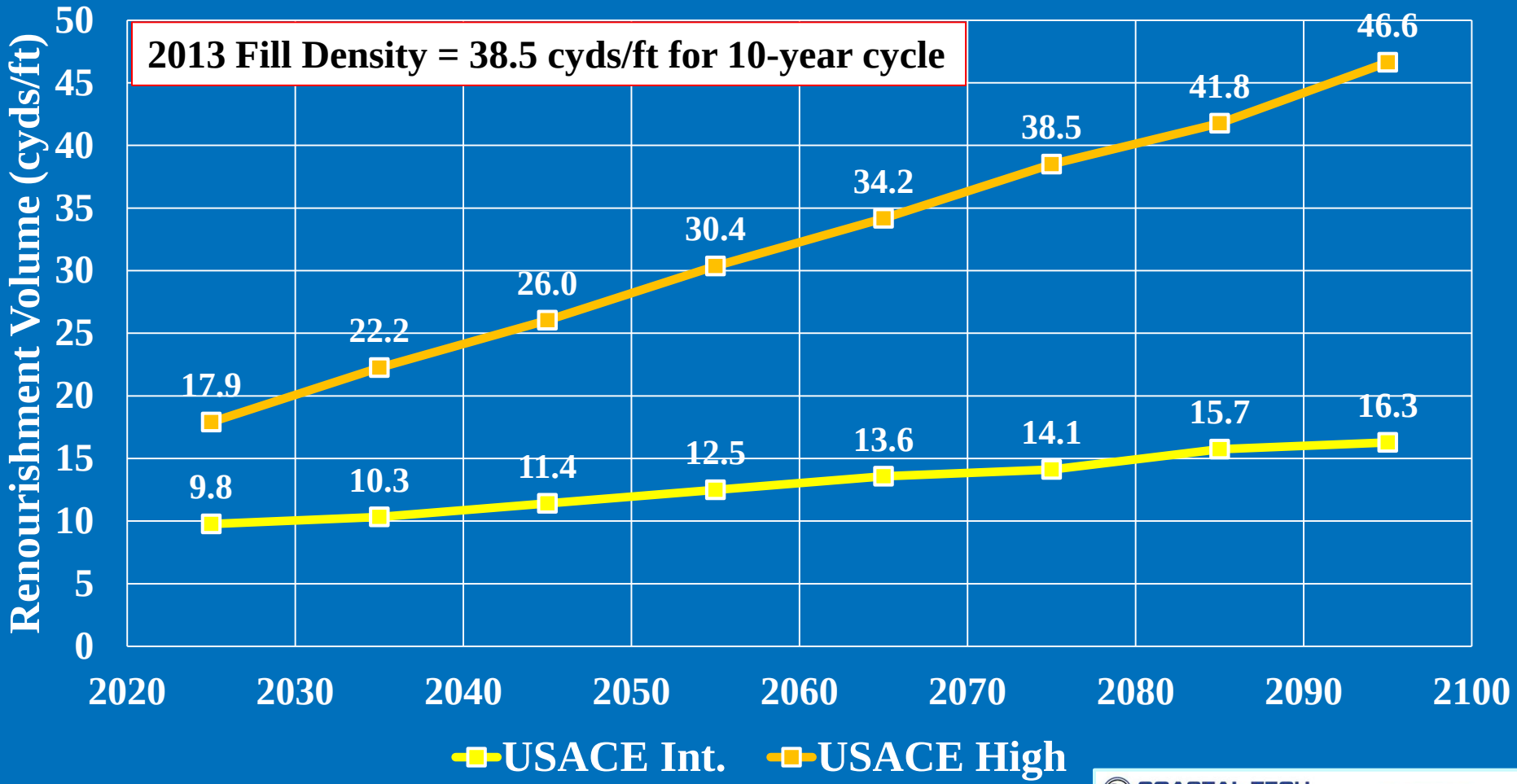


Effectiveness of Beach Nourishment in Response to Sea Level Rise

South County - St. Lucie County

Nourishment - future needs based on 10 year cycle

to offset longshore sediment transport gradient & sea level rise



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Effectiveness of Beach Nourishment in Response to Sea Level Rise

South County - St. Lucie County

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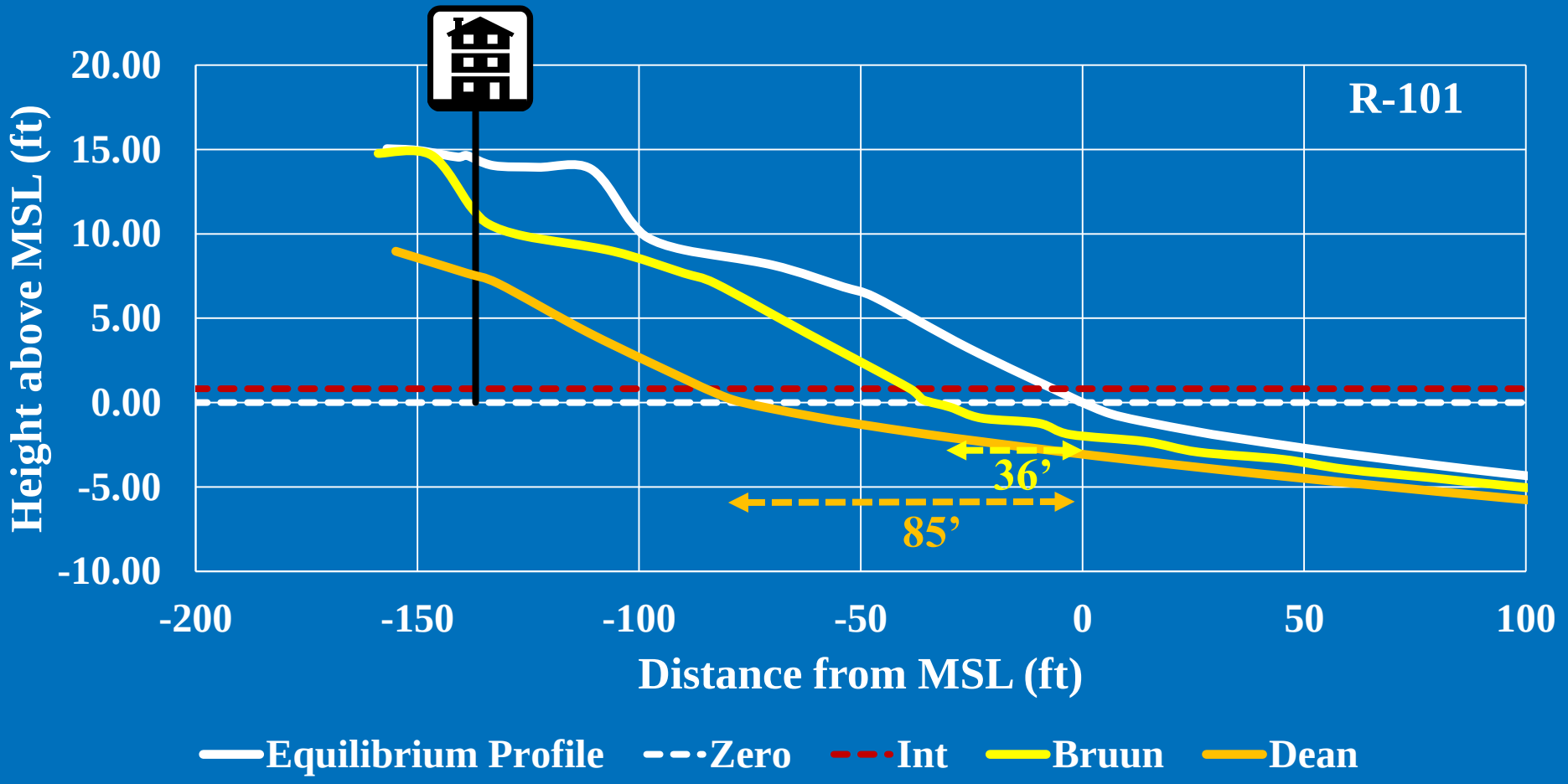
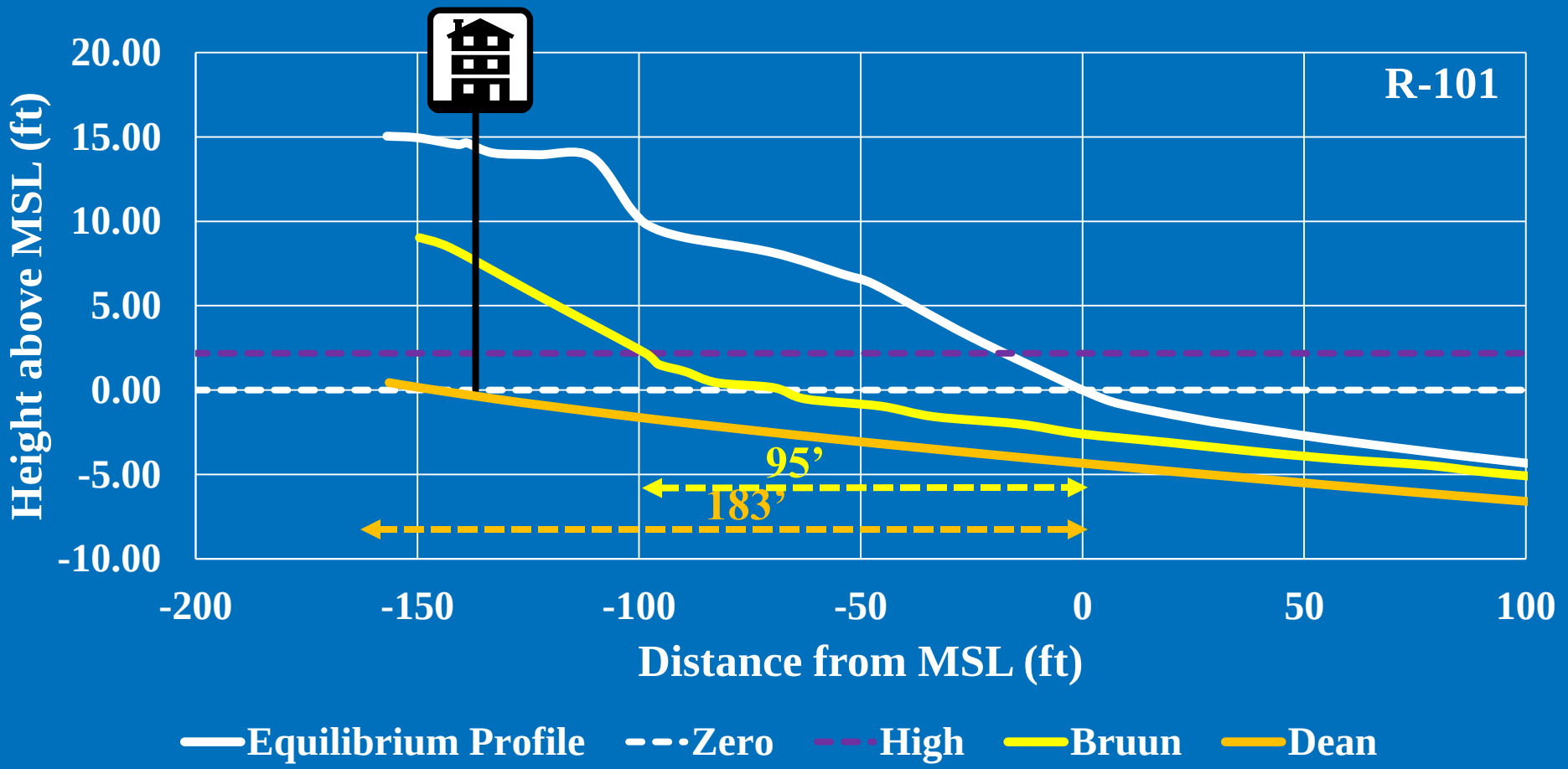


Effectiveness of Beach Nourishment in Response to Sea Level Rise

South County - St. Lucie County

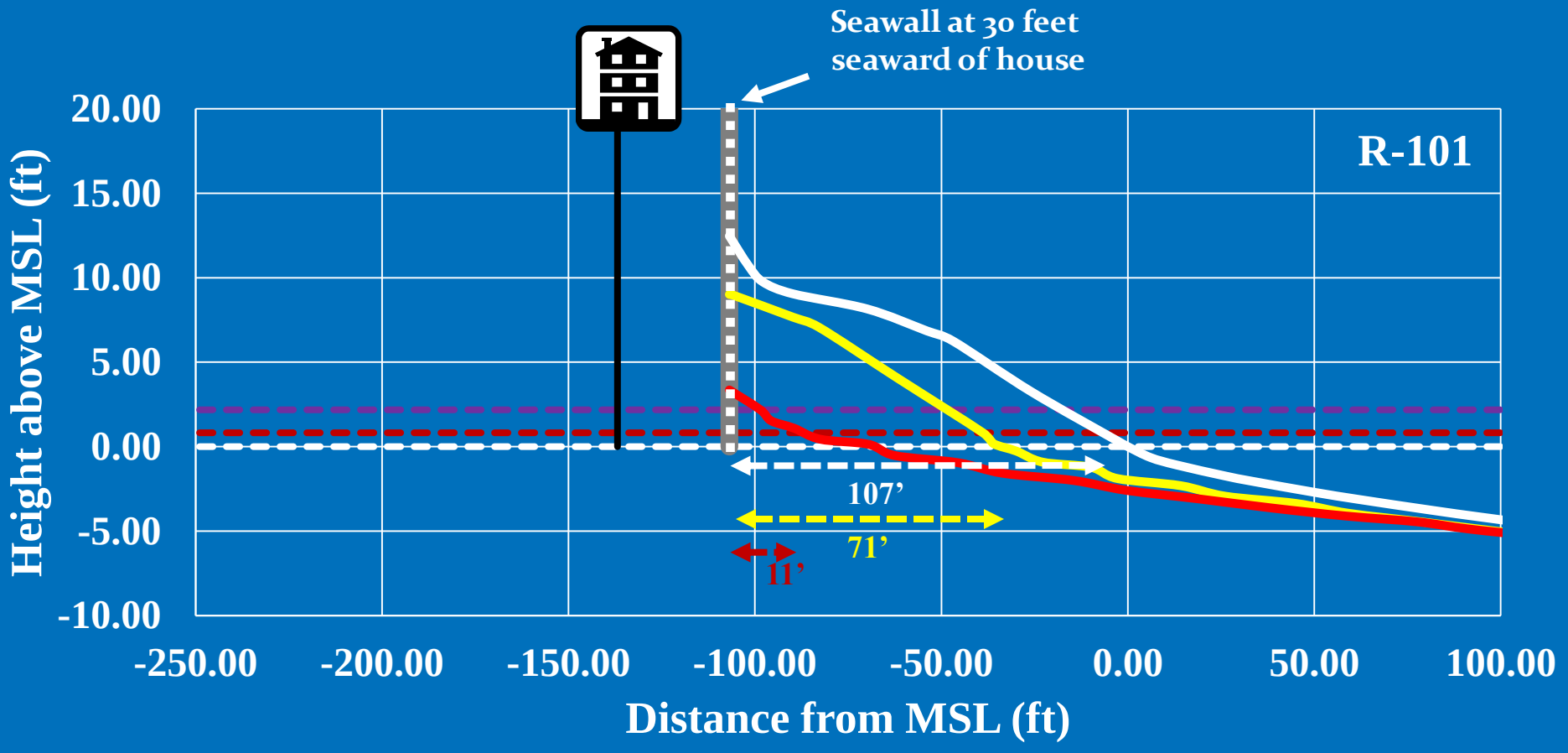
No Action – High Sea Level Change - 2065



Effectiveness of Beach Nourishment in Response to Sea Level Rise

South County - St. Lucie County

Seawall – by 2065



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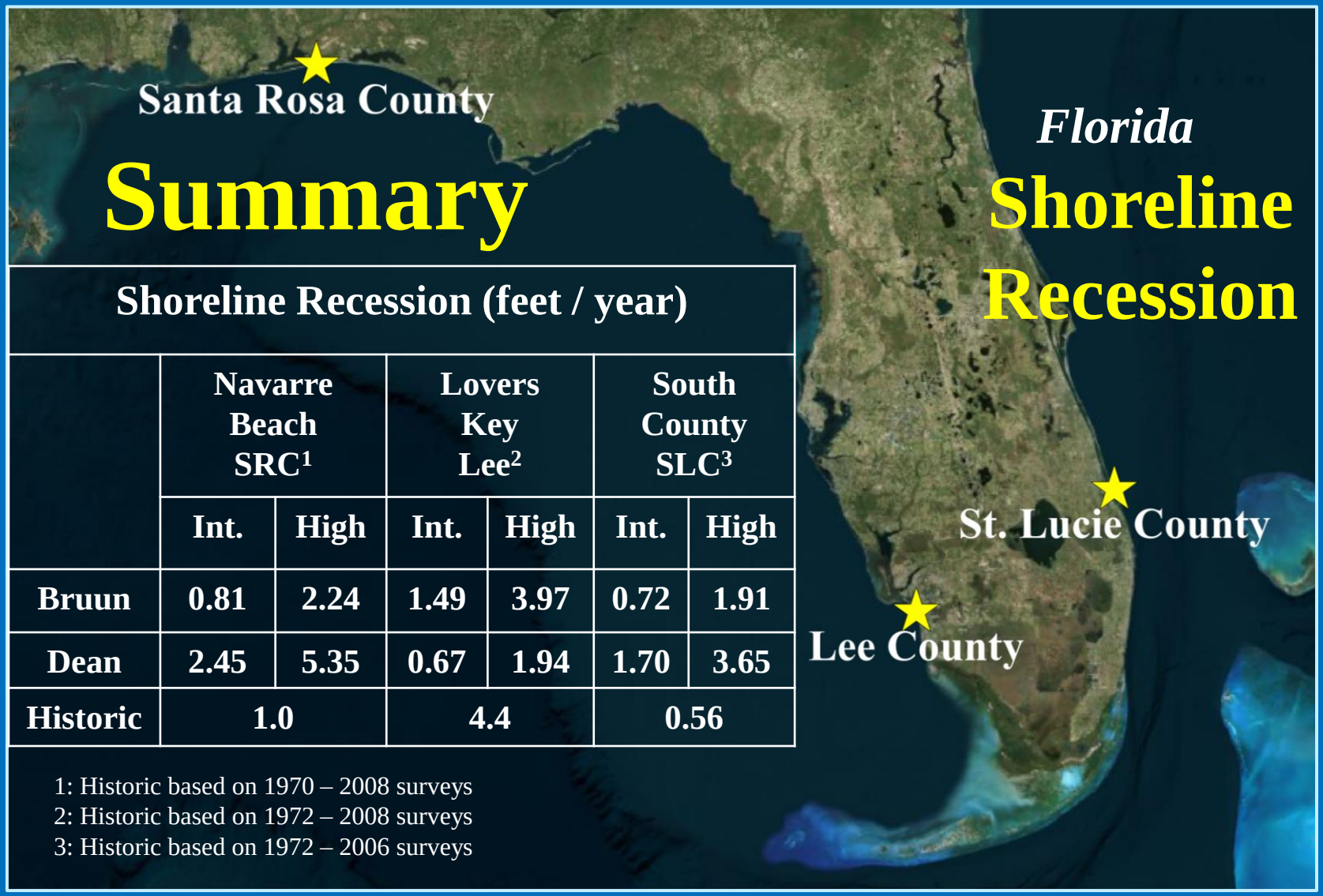

Shoreline Recession (feet / year)

	Navarre Beach SRC[1]		Lovers Key Lee[2]		South County SLC[3]	
	Int.	High	Int.	High	Int.	High
Bruun	0.81	2.24	1.49	3.97	0.72	1.91
Dean	2.45	5.35	0.67	1.94	1.70	3.65
Historic	1.0		4.4		0.56	

1: Historic based on 1970 – 2008 surveys
2: Historic based on 1972 – 2008 surveys
3: Historic based on 1972 – 2006 surveys

Historic data from: Absalonsen, L. and Dean, R. G., 2010. "Characteristics of the Shoreline Change Along the Sandy Beaches of the State of Florida: An Atlas."

Summary

	Classic Beach Management Objectives			
Alternative	**Protection**	**Preserve Land**	**Recreational Beach**	**Habitat**
Beach Fill	**Yes**	**Yes**	**Yes**	**Yes**
	limited by Design	MHWL fluctuates	beach width fluctuates	habitat fluctuates
Retreat	**No**	**No**	**Yes**	**Somewhat**
	"demolished/ relocated"	MHWL recedes	width same & migrates	loss of upland habitat
Seawall	**Yes**	**Somewhat**	**No**	**No**
	limited by Design	landward of seawall	beach width diminishes	loss of beach habitat

Conclusions

- Sea level change is estimated to rise 0.36 feet to 2.84 feet in Florida over the next 50 years.
- Over the next 50 years, fill quantities needed to offset sea level rise are within range of historical values.
- Beach nourishment is the only viable alternative to meet *classic* Beach Management Objectives.
- A better understanding of the effects of sea level rise upon beach nourishment is warranted.

Thank you

Questions?